BLAST FURNACE TUYERE AND
METHOD OF OPERATING SAME

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ABSTRACT

A blast furnace tuyere having a nose portion and a
rear portion, each of which are independently water
cooled by separate circulation systems. The nose
portion thereof comprises nothing more than helically
wound tubing, with each end thereof extending back
through the rear portion to provide an inlet and outlet
for the cooling water.

1 Claim, 6 Drawing Figures
BLAST FURNACE TUYERE AND METHOD OF OPERATING SAME

BACKGROUND OF THE INVENTION

Because of the excessive heat to which they are subjected, it is well known that blast furnace tuyeres are relatively short-lived. Although many tuyere designs have been advanced through the years in attempts to extend tuyere life, improvements have not been greatly significant. Tuyeres of even the most advanced designs typically last no more than about 85 to 100 days during continuous operation.

It is also well known that tuyere failure most commonly occurs in the nose portion thereof where the tuyere comes into direct contact with the hot molten metal and/or slag within the furnace. Even though tuyeres are usually water cooled, continuous furnace operation soon creates conditions whereby the cooling water is incapable of preventing failure. That is, in normal operation, tuyeres operate with nucleated boiling of the cooling water in the nose portion. Sooner or later, there is sufficient heat loading on the tuyere nose to cause the cooling water to go into film boiling. Film boiling results in a lower heat transfer from the adjacent surface, causing a rapid increase in temperature.

When the melting temperature of the tuyere material is reached, failure or burn-out begins. When a tuyere failure does occur, the cooling water enters the furnace charge causing a temperature drop as well as other complications due to the rapid boiling thereof. It is therefore imperative that upon tuyere failure, the cooling water supply should be shut-off and the failed tuyere immediately replaced.

SUMMARY OF THE INVENTION

An object of this invention is to provide an improved, longer life, blast furnace tuyere having independent forward and rearward cooling chambers so that the nose portion and the rearward portion are cooled by separate systems to thereby increase cooling efficiency, particularly in the nose portion, and to permit continued, though limited, operation even after the nose portion has failed.

Another object of this invention is to provide a blast furnace tuyere having separate forward and rearward cooling chambers in which at least the forward chamber comprises unprotected helically wound tubing to increase heat transfer efficiency and prolong tuyere life.

A further object of this invention is to provide a blast furnace tuyere having a nose portion which is readily separable from the rear portion so that upon failure of the nose portion, the tuyere can be easily repaired merely by replacing the separable nose portion.

These and other objects and advantages will become apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an outside end view of a blast furnace tuyere in accordance with one embodiment of this invention;

FIG. 2 is a sectional side view of the blast furnace tuyere shown in FIG. 1 taken at line II—II;

FIG. 3 is a sectional view of the wall of the tuyere shown in FIG. 1, taken at line III—III;

FIG. 4 is another sectional view of the tuyere wall taken at line IV—IV, FIG. 1;

FIG. 5 is a further sectional view of the tuyere wall taken at line V—V; and

FIG. 6 is a sectional side view of a blast furnace tuyere in accordance with another embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIGS. 1 through 5, one embodiment of the blast furnace tuyere of this invention comprises a rear member 10, having frusto-conical walls 12 defining an air blast opening 14 therethrough, and a frusto-conical nose member 30 consisting of helically wound tubing 32 forming an extension of the air blast opening 14.

The rear member 10 is formed of cast metal, preferably copper or alloys thereof, and although the outer surface is substantially frusto-conical in configuration, the air blast opening 14 is frusto-conical only in the forward part thereof. That is, a heavy flange 16 is provided around the inside portion of walls 12 to provide a flat ring shaped surface 18 at the base of member 10, as shown in FIG. 2. A chamber 20, for receiving cooling water, is provided within walls 12 partially encircling opening 14. An inlet port 22, communicating with chamber 20, is provided through surface 18 to admits cooling water into chamber 20. Similarly, an outlet port 24 is provided through surface 18 to discharge water from chamber 20. If desired, a gas port 26, as shown in FIG. 2, may be provided through wall 12 to introduce natural gas into the hot air blast passing through opening 14.

The nose member 30 is preferably formed from stainless steel tubing, and is secured to the small forward end of rear member 10 by any suitable means such as spot welding. The helically wound tubing 32 is wound and positioned so that the windings form an extension of walls 12 and opening 14. Both ends of the helical tubing 32 extend back within opening 14 to provide a cooling water inlet and outlet. Specifically, a cooling water inlet pipe 34 is provided by extending the forward end of tubing 32 back through opening 14 parallel to inside wall 12 and through flange 16 to inlet port 36. Similarly, a cooling water outlet pipe 38 is provided by similarly extending the other end of tubing 32 to outlet port 40. A continuous weld and/or high temperature adhesive should be applied between tube layers to prevent the hot blast from exiting therebetween.

In operation, the tuyeres are of course inserted into openings in the blast furnace side wall (not shown) and a blow pipe (not shown) is secured against opening 14 at surface 18. A pair of water inlet lines (not shown) are connected to inlet ports 22 and 36, and a pair of outlet lines (not shown) are connected to outlet ports 24 and 40.

The cooling water circulating through nose member 30 is first admitted to the extreme forward end thereof so that the water at its coolest temperature is first subjected to the hottest part of the tuyere where maximum heat transfer is most essential. Since the nose member 30 comprises nothing more than coiled tubing 32, the cooling water passing therethrough has a smooth unob-
structured path with no sharp corners, pockets or restrictions, thus allowing water flow with a minimum resistance and hence optimum cooling efficiency. Furthermore, since the cooling water passing through nose member 30 does not also serve to cool the base portion 10, the resistance to water flow is even further minimized. The rear member 10 is of course water cooled independently. Since the cooling water passing through rear member 10 is not preheated by first passing through the nose member 30, the rear member 10 is kept cooler than those tuyeres having a single cooling system, and will therefore help to keep nose member 30 somewhat cooler. All these factors will combine therefore to keep nose member 30 cooler than has been possible with prior art tuyeres, and hence enhance the life of the tuyere. That is, the cooling water in the nose member 30 of the above tuyere develops a much higher velocity at lower flow rates than can prior art tuyeres. The increased water velocity of course increases heat transfer from the tube 32. The water velocity obtained in conventional tuyeres is generally less than 2 feet per second at volumetric flow rates of 25 gpm, whereas the above tuyere develops a water velocity of about 20 fps in the nose member 30 at a flow rate of only 15 gpm. This provides a further advantage in that less water per unit of time will enter the blast furnace in the event of failure.

Upon continued operation, the nose member 30 will of course fail eventually. Because of the double cooling system, however, the furnace operator may, if he wishes, merely shut off the cooling water to the nose member 30. Although this will cause the nose member 30 to be quickly melted away, the rear member 10 would still be water cooled, and hence the operator could continue to operate the furnace without interruption for a limited time until a more opportune time for a tuyere change.

Since rear member 10 would remain intact after failure of the nose member 30, it would of course be possible to reuse rear member 10 by merely replacing a new nose member 30 thereon.

In order to realize the primary object of this invention, i.e., enhanced tuyere life, certain structural and operating conditions must be met. The table below provides the essential structural and operating conditions to this end and the preferred values therefor.

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<th>TABLE</th>
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<tr>
<td><strong>Essential</strong></td>
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<tr>
<td>Thermal Conductivity of Fabricating Material</td>
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<tr>
<td>Btu/ft-hr-F</td>
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<tr>
<td>Tube Wall Thickness</td>
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Another embodiment of this invention is shown in FIG. 6 and is substantially the same as the embodiment described above except that the rear member 10A is formed from helically wound tubing as is the nose portion 30A. In this embodiment, inlet and outlet pipes for the cooling water are disposed outside the frusto-conical tuyere walls merely to show an alternate position therefor.

Considering the second tuyere embodiment in more detail, the rear member 10A comprises helically wound tubing 50 axially secured to an annular base flange 52. Base flange 52 is made entirely of plate metal, i.e., two discs 54 and 56, each having a circular hole therethrough, horizontally spaced apart by sleeve members 58 and 60. The structure thereby forms a portion of the air blast opening 14A having an annular chamber 62 therearound. The inner sleeve member 58 extends beyond disc 56 to provide a sleeve over which rests the helically wound tubing 50. The ends 64 and 66 of tubing 50 extend back through base flange 52 to provide a water inlet and outlet respectively to the helical portion of tubing 50. Similarly, the ends of tubing 32A forming the nose portion 30A must extend back through base flange 52 to provide a water inlet and outlet for the nose portion 30A. At least three confine-

mnet tubes 68, or other suitable means, should be provided within chamber 62 to prevent the water from mixing therein. In operation, this tuyere functions substantially the same as described above for the first embodiment.

We claim:

1. A blast furnace tuyere comprising a rear member and a nose member joined together to form a single air blast opening therethrough, said rear member formed of a cast material and having a base portion and a substantially annular chamber therein and openings through said base portion for circulating cooling water through said chamber, said nose member being formed of helically wound tubing having linear end portions thereof extending back through said air blast opening and through said base portion of the rear member for circulating cooling water through said tubing independently of said openings for circulating cooling water through the chamber in said rear member.* * * *